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Circular Economy in China: Towards the Progress

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Abstract

At present all nations are thinking about the circular economy (CE) in production, circulation, and consumption due to environment pollution and resource scarcity. But implementation of CE policy is yet in its infancy. The CE in the form of waste management policy that is achieved in selected developed countries of the world. China is a developing country in the East Asia. The economy of China has grown with an average 10% per annum during the last 30 years that contributes important impacts on the world economy. At the last quarter of the 20th century and beginning of the first quarter of the 21st century China becomes the largest energy user in the world, as the country rapidly becomes the largest exporter in the world. To produce essential commodities according to the global demand the country mainly depends on coal and fossil fuel to create electricity, consequently it emits maximum CO₂. Recently, China has faced various harmful odd situations, such as environmental degradation, human health and social problems due to huge population, and source scarcity for the huge production, rapid continuous unplanned

urbanization, and growing economy. Thinking for future sustainable economy and human welfare of the country, China is attracted by the CE. The country has taken various attempts to implement CE at the three levels at a time, namely micro, meso and macro levels.

Keywords: 3R Principle, China, Circular Economy, Economic Sustainability, Environmental Problems

1. Introduction

The official name of China is People's Republic of China (PRC). It is a sovereign state in East Asia with total area 9,596,960 km², bordering with 14 countries and 4 seas (bays) (Figure 1). Beijing is its capital city and Shanghai is the largest city. Its official language is Mandarin. The country is officially divided into 23 provinces. It is in the first rank in the world for populations and its population is about 1,446,120,273 (about 3.3% people live below poverty line whose income is \$1.90 per person per day), and 60.8% lives in urban. Its GDP is \$25.36 trillion that is about 11.6% of the total global GDP, life expectancy in 2021 is 77.13 years, and literacy rate is 97% [6].

China has a fair civilization from very ancient time. Recently, the people of China have made serious harm on the nature due to rapid industrialization in the country. Since 2005, economy of China has grown at an average rate of 10.6% per year [30]. In 2004, China became the world's largest waste generator overtaking the USA [42]. Very sensitive problems, such as deforestation, water depletion, desertification, land degradation, loss of biodiversity, climate change, etc. are facing the country. The shortage of natural resources

and energy can reduce future economic growth in China. High energy and resources consuming bring new future in the Chinese industrial structure [25].

The government of China (GoC) has accepted CE for the sustainable economic structure since 2002. China offers a window into how top-down national policy can produce change, while EU follows bottom-up policies [38]. In 2003, GoC adopted a legislative package that the companies, who are polluting the local and global environment, are required to develop their production strategies, to reduce environment pollutions [45]. In 2008, CE policy of China was established through the “Circular Economy Promotion Law”, which



Figure 1. Map of China. Source: [6].

was projected to guide China’s economic development in ways that save energy, water and

materials, and defend the environment, and in 2009 this law has been passed. It proposed a closed-loop of all materials in every stage of production, distribution, and consumption processes [14].

The strategy of GoC is to implement the CE in the Chinese society based on three supports: i) a production that is environmental favorable, ii) industrial ecology, and iii) ecological modernization [22]. The CE practices of China categorized into four main portions: 1) production, 2) consumption, 3) waste management, and 4) other support. Besides, China stresses on energy effectiveness and maintenance, land controlling and soil fortification and integrated water resource management as important issues [38]. In China apply of CE begins at the grassroots level of enterprises (micro-level), then it is applied industrial parks (meso-level), and finally it is expanded to cities and regions (macro-level). Aim of implementation of CE in the country is to furnish the environment fruitfully, present a resource-saving and environment friendly society, and to achieve a proper economic growth among population, resources, and the environment [46].

China is rich in natural resources. It has 1.8% of the world's total oil reserves, 0.7% of natural gas, 9% of iron ore, 5% of copper ore, and 2% of aluminum. But the country has a vast population, per capita major resources of China are below the world's average level [27]. Per capita resources of it are as follows: half the world average in mineral resources, one-third in arable land and grassland, one-fourth in water resources, one-fifth in forest, one-seventh in energy, and only one-tenth in oil. In 2006, steel consumption in China was 250 million tons, which is equal to the combined total of the USA, the EU, and Japan, and almost 40% of the world's total; cement use was 800 million tons that is almost half the world total and second in electric power after the USA [21]. In 2011, China produced 46%, 50%, and 60% of global aluminum, steel and cement, respectively, using 25.2 billion tons of raw materials and consuming 21.3% of global energy. In 2014, it generated 3.2 billion tons of industrial solid waste, only 2 billion tons of which was recovered by

recycling, composting, incineration or reuse. On the other hand, firms and households in the 28 countries of the EU generated 2.5 billion tons of waste in 2012, of which 1 billion was recycled. It is estimated that in 2025, China is expected to produce almost one-fourth of the world's municipal solid waste [29].

2. Literature Review

The literature review in any research is a unit where the researchers need to determine what is already realized and what is not captured yet about their research areas. Researchers can identify knowledge gaps so that they can create the consequence of the study and develop the knowledge to make the research more reliable [36]. The traditional LE must be replaced by a CE for the sustainability. Without CE the global economy in future will be fragile. For the survival of human life on the earth at all times, CE will give a better solution. LE does not support 3R principles, and it treated environment as a reservoir of wastes [3, 35]. The Ellen MacArthur Foundation, a nonprofit organization, publicly launched on 2 September 2010, represents the CE in various ways, such as regenerative design, performance economy, cradle-to-cradle, biomimicry and blue economy. It stresses that CE maintains and preserves the ecologic equilibrium and the economic growth [8].

Patrizia Ghisellini and her coauthors state that although the CE is very new in our society, it provides a reliable framework towards radically improving the present business model towards preventive and regenerative eco-industrial development [13]. Romain Pardo and Jean-Pierre Schweitzer think for a long-term vision for the CE. They want to keep the value of resources for, as long as, possible, and reuse and upgrade in production, consumption and end of life management processes. They stress that if the society moves to CE there is a vast

opportunity to save natural resources and reuse the waste and by-products; consequently stresses on raw materials will reduce [33].

We Li and Wenting Lin have discussed aspects of practices of CE policies in China from 1990 to 2020 [27]. Yong Geng and his coauthors have observed that during the last five decades China has been achieved miracle in economic development. Side by side it has faced significant burdens of global warming, resource scarcity, and local and global environment pollutions. For the sustainable development, China should follow CE policy. China is the first country in the world that took attempts to apply CE in all levels of the society [12].

Biwei Su and her coauthors have provided a detail scenario on Chinese CE that covers from the concept, current practices and assessment system. They have also discussed the challenge and barriers in the way of implementation of CE in the society [38]. Yong Geng and Brent Doberstein describe the long-term promotion of a CE in China, such as the formulation of objectives, regulation, strategies and actions, so that the country can choose a more sustainable path. They have identified a series of barriers and challenges to the implementation of CE in China [11].

Q. Z. Yang and his coauthors present the proper application of 3R principles of the CE theory in China to enable circular production and consumption in every level [44]. Yuan Hu and his coauthors show that China has been the most proactive country in the world for upgrading its economic model by enacting a Circular Economy Promotion Law (CEPL) [18]. Haradhan Kumar Mohajan in a review paper shows that the application of CE will make the society comfortable and will make the economy sustainable. He has identified that the waste and e-waste management policies, establishment of smart cities, improvement of public awareness and participation in activities related to CE can make

the world sustainable [30]. In another paper he shows that Germany has earned a lot of money by recycling, a large number of people have employed in the CE projects, stress on import of raw materials has reduced, reduces greenhouse gas emissions, reduces emissions that are seriously harmful for human health, etc. [32].

3. Research Methodology of the Study

Research methodology is the scientific procedure that researchers apply to perform their expected good researches [23]. To develop the article we have taken help from the secondary data of many sources. At the starting, we have tried to compare linear economy (LE) with circular economy (CE). We have observed that LE cannot establish a sustainable development in the society. On the other hand, CE can use the waste after recycling and upgrading and can make wastes as social assets. First Germany, then Japan, and then China have taken various attempts to implement CE in their countries. In this study we have discussed the procedures of application of CE in China. The GoC has accepted the idea of CE in 2002. It has given priority to CE in three consecutive Five-Year Plans, such as the 11th Five-Year Plan (2006-2010), the 12th Five-Year Plan (2011-2015), and the 13th Five-Year Plan (2016-2020). China takes various strategies to apply CE policy in three levels: micro level, the meso level, and macro level.

In the study we stress on cleaner production (CP) policy of China. We have also tried to give benefits and challenges in the way of implementation of CE in China.

4. Objective of the Study

The chief objective of this study is to discuss CE strategy of China in top to bottom levels. The other minor objectives are as follows:

- a. to overview CE, its origins and expansion,
- b. to indicate the sustainable development following CE strategy, and
- c. to show the benefits and challenges of implementation of CE in China.

5. Global CE Procedures

Linear economy (LE) of “take, make, and waste” became popular globally after the World War II. In linear economic model, companies increase their sales through new products and consumers enjoyed the new choices. The LE does not provide an environment friendly sustainable society. Due to LE environment pollution and global climate change have become worse [8]. In LE model 92.8 billion tons of natural resources are used in the global economy only in 2015 and it is estimated that the global demand of raw materials will reached to 186 billion tons per year by 2050. The world unable to supply this demand of raw materials; consequently, the economic development will be unsustainable. CE is blessing to the global economy, as it tries to reduce the raw material consumption and minimize the production of waste, as well as, keep the value of natural resources for as long as possible. It is expected that CE will give annual economic benefits of more than \$2 trillion globally by 2050 [40].

During the 1970s and 1980s population growth has increased wastes globally. Shortage of spaces for waste disposal awareness has created among scientists, politicians and

industrials. They come together to tackle the problem of waste management. At the same time scarcity of raw materials has increased due to growing of many industries and economic development. Many countries tend to uphold the value of products, materials, and resources as a step of CE to prevent pollution and minimize waste production [7, 17]. At present the global CE policy is at the beginning and all nations come ahead to apply CE in all steps of the society. The global CE should focus on recycle rather than reuse. The EU, very limited countries of North and South America, few countries of Asia took various steps to implement CE first in locally and then globally [38].

The idea of CE came first from two Britain environmental economists David W. Pearce and R. Kerry Turner in 1990 in their book *Economics of Natural Resources and the Environment*. Their attempt was to establish sustainable economy and clean environment in society [35]. Germany is the first country that implemented CE in 1996. The first law “*The German Closed Substance Cycle and Waste Management Act*” for WM was enacted in 1994 and replaced in 1996 by the *Kreislaufwirtschafts- und Abfallgesetz (KrW-/AbfG)*, “*Closed Substance Cycle and Waste Management Act*” [2]. The law was amended and renamed in 2012 to the *Kreislaufwirtschaftsgesetz (KrWG)*, “German Resource Efficiency Programme (ProgResS)” CE law [24].

Japan implemented CE since 1991 with the law for Effective Utilization of Recyclables [19]. In 2000, Japan has taken various attempts to establish CE in the whole country. The government of Japan (GoJ) has stressed to elevate the nation in super position in production, consumption and waste management into a “recycle-oriented society” [41]. China is the third country after Japan in the world that has tried to apply CE efficiently nationwide on a large scale. Its CE policy was to form a more sustainable economic structure in the country. CE reduces stress on raw materials and reduces waste, and makes the waste into raw materials. As a result CE makes an ecological balance in the society

[15]. The European Commission has announced a €24 billion CE Package in December 2016. As a result, many new jobs have created and the economy has advanced in a sustainable way [10].

The USA has started zero waste projects in locally in the limited areas. The country has stressed on use the raw materials of one factory will be the waste of another factory [4].

6. CE in China

Chinese has primarily learned from the CE strategies of Germany and Japan, and it has taken CE policies in a broad range [41]. In 1998, some researchers of China have proposed the concept of a CE [47]. Thinking for the shortage of raw materials and energy in the country and also considering the local and global environment pollution, the GoC accepted the idea of CE in 2002 as a new development strategy through the State Environmental Protection Administration (SEPA). In 2004, the National Development and Reform Commission (NDRC) was appointed instead of SEPA by the Chinese State Council to take over the duty for promoting and implementing the CE in the country [41, 45]. In 2003, the GoC has adopted first CE regulatory policy “Cleaner Production Promotion Law”. And the amended law on “Pollution Prevention and Control of Solid Waste” has affected on 01 April 2005. On 29 August 2008, the “Circular Economy Promotion Law” was approved at the 4th meeting of the Standing Committee of the 11th National People’s Congress of China that activates on 01 January 2009. It is the world’s first national law that supports CE. This law claimed that development will be in sustainable ways at every level of the state policies.

It encourages the development of the CE such a way that efficiency of resource will be

properly, environment pollution will be controlled, and development will be in a sustainable way [12]. The GoC has taken attempts to adopt the CE in the country for the national development [11]. The 11th Five-Year Plan (2006-2010) of China was devoted to the CE and it was upgraded to a national development strategy in the 12th Five-Year Plan (2011-2015). Strategy of CE in China is efficiency-oriented control in all stages of manufacture, supply and consumption process [38]. Recently, China has reduced coal-based energy production to decrease CO₂ emissions that cause global climate change [30].

Various scholars and experts argued that restricting efforts to the micro level would not be sufficient for successful implementation of CE policy in China, the extend efforts to the meso level and macro level are necessary in this regard [34, 45]. At the micro-level CE focuses on eco-design of manufacturing plants, waste minimization, environmental management systems, and cleaner production approaches. Among theses, cleaner production is considered as very essential and fruitful activity at the micro-level of the CE [11]. The industrial ecology stresses on the benefits of proper use residual waste materials [22, 45]. At micro-level CE stresses on the reduction of pollutions and reuse of wastes through better environmental management systems, cleaner production, waste reduction and improved eco-design of industrial plants [11]. At this level, firms launch ecological industrial chains by internal flow of materials and energy to yield profits by sufficient production that maximize resource use and minimize pollution [46].

At the meso-level or inter-firm level China stresses on the development of eco-industrial parks (EIPs), eco-agriculture, and networks that will be benefited both the local economy and the natural environment. In an EIP, all firms share common infrastructure and services among them and trade industrial byproducts, such as heat, energy, wastewater, and manufacturing wastes for the reduction of use of new raw materials [38]. Within an eco-industrial park, wastes or byproducts of one level of production should become raw

material or input for another by the process of waste exchange, clean production, and other measures to achieve the closed circuit circulation of materials and the multi-level use of energy, and to form an interdependent ecological industrial system. As a result, it will maximize use of materials and energy, and minimize release of wastes [46]. To encourage the development of EIPs, GoC has taken various attempts of national guidelines, through the State Environmental Protection Administration (SEPA). A typical EIP consists of many sides, such as a residential, manufacturing, scientific research and business area, where they all share the mutual benefits of a CE [11]. In the 13th Five-Year Plan (2016-2020), more than 75% of national industrial parks and more than 50 provincial industrial parks should be practicing complete circular strategies by 2020. It is expected that the output value of the recycling industry will reach to \$450 billion [26]. In the agricultural sector, eco-agricultural system aims to utilize byproducts and wastes from crops and livestock. The green designs of residential communities of China reduce energy, water, and land consumption for the cleaner production and development of CE [45].

At the macro-level or social level, CE stimulates both sustainable production and consumption activities in the country through the development of eco-cities and eco-provinces that attempt to create a recycling oriented society [12, 25]. The CE cities and provinces are involved with four systems as: i) the industrial system, ii) the infrastructure, iii) the cultural setting, and iv) social consumption. Pollution prevention becomes dominant task at cities and provinces [46]. The GoC helps these types of agencies through privileged industrial recruitment and financial policies, such as land subsidies and tax incentives [11].

As like EU China's national CE policies are based upon the 3R principles: Reduction, Reuse and Recycle in all steps of production, circulation, and consumption of products. Reduce indicates the minimization of the input of raw materials and energy during all types of productions by the improvement of production efficiency. Reuse indicates the proper use of the byproducts and wastes from one industry as resources for other industries. Recycling is the processing of the materials into new products to prevent waste

of potentially useful materials [49]. For example, the Suzhou New District, near Shanghai, manufacturers of printed circuit boards use copper that is recovered from waste from elsewhere in the park, rather than using virgin copper [29].

In the 11th Five-Year Plan (2006-2010) of China took attempts to advance resource saving technologies and to preserve the environment and achieve a harmonious balance of economic growth, natural and manmade resources, as well as, the population and the environment [46]. In the 12th Five-Year Plan (2011-2015) of China targeted to reuse 72% of industrial solid waste by 2015. The plan encouraged for recycling industrial wastes, development of industrial parks, remanufacturing, city cleaning, and the development of waste management and recycling systems [37].

The 3R principles are accomplished by reform and reorganisation of city's infrastructure and industrial design in according to regional characteristics. Further development or fully closing of the factories or enterprises are needed those are highly polluting, and also develop high-tech industries for the sustainable development. By applying the 3R principles, the GoC can minimize wastes in an efficient way that leads to the reduction policies of overall resource consumption [48].

Chinese governmental agency National Development and Reform Commission (NDRC) prepares various national CE policies, such as drafting of related legal documents, selecting of national CE projects, establishing of national CE indicators, and coordinating and communicating of CE-related issues with other relevant agencies [43]. CE policy of China is a sustainable development strategy that aims to improve the efficiency of materials and energy use in future productions [49].

Recently, Xiongan city of Hubei province is planned for the largest and ambitious of the

demonstration sites of circular solutions. It is intended to serve as a role-model for city planning and for sustainable solutions by implementing CE in China for the coming decades [5].

7. Cleaner Production

The concept of cleaner production (CP) was introduced for the first time by The United Nations Environment Programme (UNEP) Industry and Environment in 1989. It is started for the improvement of environmental efficiency which has positive economic and social benefits [20]. The UNEP defines cleaner production as [39] *“The continuous application of an integrated preventive environmental strategy to processes and products to reduce risks to humans and the environment. For production processes, cleaner production includes conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes before they leave a process. For products, the strategy focuses on reducing impacts along the entire life cycle of the product, from raw material extraction to the ultimate disposal of the product.”*

CP is a strategy for the improvement of natural resource efficiency, reducing and eliminating policies of wastes and pollution, and minimizing strategy of risks that are related to human health. It always encourages minimizing waste and emissions, and maximizing product output [1]. It monitors pollution, as well as, efficient use of resources at all states of the production and consumption. It plays an important role for the reduction of environmental externalities and their energy intensity for the welfare of the global humanity [16]. Improvement of CP in the society is the most fruitful and successful strategy of China [11].

CP strategies are removing toxic byproducts from the production line, reduce of pollutants throughout the life cycle of a product and include sustainability concerns when designing or delivering finished products [20]. At present, CP initiatives have been implemented in the 24 provinces of China that cover various industrial sectors, such as pharmaceuticals, transportation, metallurgy, chemical, machine manufacturing, and textiles [11].

8. Benefits and Challenges to Implement of CE

In the way of implementation of CE China has gained variety of benefits, such as economic, environmental and social welfares. CE helps eco-industrial parks and cleaner production efforts in institutionalization as long-term development strategies [12]. China's CE develops unemployment problems in all steps of the society, equals distribution of economic growth and improves people's overall well-being [48].

The CE strategies should be designed according to the needs of the Chinese citizens, such as housing, mobility, health and nutrition. It is estimated that CE will create 1.2 million to 3 million jobs in Europe that will reduce equilibrium unemployment about 250,000 to 520,000, will earn about €114 billion to €324 billion, and reduce raw material demand from 70 to 184 million tons, respectively by 2050 [28]. The CE benefits China to unify populations, proper use of resources, and the environment, stimulate social justice at a higher level, prevent environmental poverty, and narrow the income gap between the rich and the poor [46]. One ton of mobile and smart phones (about 6,000) contain about \$28,000 of gold, silver, copper and palladium. By extracting valuable metals from e-waste China can be benefited economically and environmentally [9].

To implementation CE China faces some problems, such as lack of social indicators,

urban/industrial symbiosis, prevention-oriented indicators and absolute energy/material reduction indicators, as well as, barriers to implementation of CE [12].

9. Conclusions and Recommendations

During the last few decades there was an enormous change in China due to rapid urbanization and industrialization. The country became the second largest economy after the USA. Recently China is facing various environmental challenges, such as global warming, resource scarcity, and environmental pollution. For the sustainable development, the country follows various green steps giving priority to CE. At present China wants development of three areas in parallel: economic development, improvement of environmental quality, and social development. Implementation of CE can help in this regard. The CE reduces pressure on natural resources.

Application of CE in China is still low and most Chinese industries are still in early development stages. Application of CE in all spheres of China will improve the overall well-being in the society, will strengthen the national sustainable development and will advance the nation's modernization. To build an environment friendly, resource saving, and sustainable economy, and to make a social welfare atmosphere, China should follow CE practices. If China does not follow CE efficiently in all sectors, it will face the challenges of natural resources, environment pollution, national competitiveness, and economic security.

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